

4 Population Ecology

Before you read the chapter, answer each question with information you know. After you complete the chapter, re-answer the questions using information you learned.

BIGQUESTION How Do Changes in Population Size Relate to Environmental Conditions?

	What I Know	What I Learned
<p>4.1 How do ecologists organize and study life?</p>	<p><i>Sample answer: Scientists organize life by grouping organisms into categories based on similarities and differences.</i></p>	<p><i>Sample answer: Ecologists study life at different levels—individual, population, community, ecosystem, and biosphere. They study how organisms interact at each of these levels.</i></p>
<p>4.2 What are the important characteristics of populations?</p>	<p><i>Sample answer: Organisms in populations live together and interact with each other.</i></p>	<p><i>Sample answer: Populations can be analyzed and described in terms of size, population density, population distribution, and sex ratio.</i></p>
<p>4.3 What factors determine whether, and how, a population's size changes?</p>	<p><i>Sample answer: Resources such as food and water help determine if a population size changes.</i></p>	<p><i>Sample answer: Population growth rate is determined by births, deaths, immigration, and emigration.</i></p>

4.1 Studying Ecology

Key Concepts

-  Ecologists study life at many levels, from individual organisms to the entire biosphere.
-  Ecosystems include both biotic and abiotic factors.
-  Organisms depend on resources provided by their habitat for survival.



SKILL BUILDER Vocabulary Preview

Define each vocabulary term in your own words. Then, write yourself a quick note on how you will remember each. One term has been done for you.

Term	Definition	How I Remember
Ecology	<i>The study of how organisms interact with each other and with their environments</i>	<i>Accept all reasonable responses for How I Remember. A few samples are provided.</i>
Species	<i>A group of individuals that interbreed and produce fertile offspring</i>	
Population	<i>Members of a species that live in the same area at the same time</i>	
Community	<i>All the populations in a particular area</i>	
Ecosystem	<i>All the living things and their physical environments within a particular area</i>	<i>I can think about the meaning of the word ecosystem by thinking of ecology and system.</i>
Biosphere	All parts of planet Earth that host life, with all of its organisms and environments	I think of <i>bio</i> , which means “life” and <i>sphere</i> , which is a round object, such as Earth.
Biotic factor	<i>Part of an ecosystem that is living or used to be living</i>	<i>Bio means “life” and a factor is a part, so a biotic factor is a living part of the ecosystem.</i>

Term	Definition	How I Remember
Abiotic factor	<i>Part of an ecosystem that has never been living</i>	
Habitat	<i>The specific environment in which an organism lives</i>	<i>The word habitat reminds me of the word inhabit, which I know means "to live in."</i>
Resource	<i>Anything an organism needs</i>	

Levels of Ecological Organization

For Questions 1 and 2, circle the letter of the correct answer.

- The most basic level of ecological organization is a(n)
 - biosphere.
 - individual.
 - ecosystem.
 - population.
- The study of living and nonliving components of a system can best be described as a(n)
 - abiotic factor.
 - level hierarchy.
 - ecosystem ecology.
 - organism interaction.
- Describe how a species is commonly defined. Explain why the common definition for species may be problematic for some organisms, such as bacteria.

A group of organisms that interbreed and create fertile offspring is considered to be of the same species. This definition, however, does not work well for organisms that do not reproduce sexually, such as bacteria. Due to problems with the definition, most biologists now define species on the basis of genetic similarity.

- What is community ecology? Give examples.

Community ecology is the study of interactions among species. It can be as simple as how a single bee pollinates a single flower or as complex as how entire herds of animals interact as they migrate across a vast desert.

Biotic and Abiotic Factors

5.  **Organize Information** Fill in the T-chart with examples of abiotic and biotic factors in an ecosystem. *Answers will vary. Sample answers appear below.*

Abiotic Factors	Biotic Factors
Oxygen	Bacteria
Water	Rotting trees
Carbon	Plants
Light	Animals
Temperature	People
Wind	Insects
pH	

6. Is a fallen, rotting tree considered an abiotic or biotic factor? Explain.

A biotic factor is something that is living or used to be living. A fallen, rotting tree would therefore be considered a biotic factor because it was once living.

Habitat

For Questions 7 and 8, complete each statement by writing in the correct word.

7. A cloud forest's soil, rocks, leaf litter, humidity, plant life, and seasonal pools of water are all part of a toad's **habitat**.
8. Habitats provide organisms with the **resources** they need to live, such as food, shelter, breeding sites, and mates.
9. Compare and contrast an ecosystem and a habitat.

An ecosystem and a habitat are similar because they both include the environment surrounding an organism. However, unlike an ecosystem, a habitat's boundary depends on the particular organism whose habitat it is. A habitat may be a subset of an ecosystem, or may include many ecosystems.

10. Explain the importance of resources and suitable habitats to an organism.

An organism's survival depends on having a suitable habitat where it can live, as well as the availability of resources within that habitat. Without a suitable habitat and resources, the organism cannot live.

11. Name at least two specific elements of the golden toad's cloud forest habitat.

Sample answers: Forest's soil, rocks, leaf litter, humidity, plant life, seasonal pools of water



SKILL BUILDER Organize Information

12. Fill in the table to explain how each concept applies to the golden toad.

Concept	The Golden Toad
Population	<i>All golden toads in the Monteverde region of Costa Rica</i>
Community	<i>All plants, animals, fungi, and microorganisms in the same area as the golden toad</i>
Ecosystem	<i>The surrounding community, plus the physical environment in which the golden toad lived</i>
Habitat	<i>The Monteverde cloud forest</i>
Resource	<i>Food, water, living space, and other toads that were mates</i>

Extension On a separate sheet of paper, create another table like the one above. Use the same headings for the left column, but choose a different organism. Write the name of the organism at the top of the table and then complete the rest of the table as it applies to the organism you chose. **Check students' work.**

4.1



SELF-CHECK

Answer the questions to test your knowledge of lesson concepts. You can check your work using the answers on the bottom of the page.

13. Explain why organization is important to the study of ecology.

14. Why are dead or decaying organisms still considered important parts of an ecosystem?

15. What makes up an organism's habitat?

13. Ecologists use levels of organization to study how organisms interact with each other and their environment. 14. They are taken in and used as essential materials for living organisms. 15. The specific environment, including biotic and abiotic elements, around an organism makes up its habitat.

4.2 Describing Populations

Key Concepts

-  The overall health of a population can often be monitored by tracking how its size changes.
-  A population's density is a measure of how crowded it is.
-  Populations can be distributed randomly, uniformly, or in clumps.
-  Age structure diagrams show the number of males and females in different age groups within a population.



SKILL BUILDER Vocabulary Preview

Define each vocabulary term in your own words. Then, write yourself a quick note on how you will remember each. One term has been done for you.

Term	Definition	How I Remember
Population size	The number of individual organisms present in a given population at a given time	Accept all reasonable responses for How I Remember. A few samples are provided.
Population density	The number of individuals within a population per unit area	I visualize a very dense forest; there are many trees packed into a small space.
Population distribution	How organisms are arranged within an area	I think of the population structure of my community.
Age structure	The relative numbers of organisms of each age within a population	
Age structure diagram	A visual tool used to show the age structure of populations	
Sex ratio	A population's proportion of males to females	I recall that a <i>ratio</i> is a proportion between two things and that an organism's sex refers to whether it is male or female.

Population Size

For Questions 1–3, complete each statement by writing in the correct word.

1. When a population size **increases** _____ or remains steady, this is often a sign of a healthy population.
2. If a population size begins to **decline** _____ rapidly, this can be a signal that extinction is coming.
3. Instead of counting each organism individually, ecologists use **sampling** _____ methods to estimate population sizes.
4. Explain why the passenger pigeon, which was once the most abundant bird in North America, disappeared completely.

People began cutting down the forests where passenger pigeons lived and bred. This provided easy access to the pigeons for hunters, and the pigeons became a popular food. The population size dwindled to the point that pigeons could no longer form the large colonies they required to breed effectively, so they became extinct.

5. Describe how you could determine the population size of a specific type of plant in a large forest without counting all of the plants.

You could count the number of the specific plant type in a small section of the forest and then multiply that amount to estimate the total number in the forest.

Population Density

For Questions 6 and 7, circle the letter of the correct answer.

6. A population's density describes how

A. old the population is.	C. big the population is.
B. crowded the population is.	D. fast the population is declining.
7. Which piece of information is used along with population size to calculate population density?

A. area	C. age
B. weight	D. location
8. How can high population density be helpful to a population?

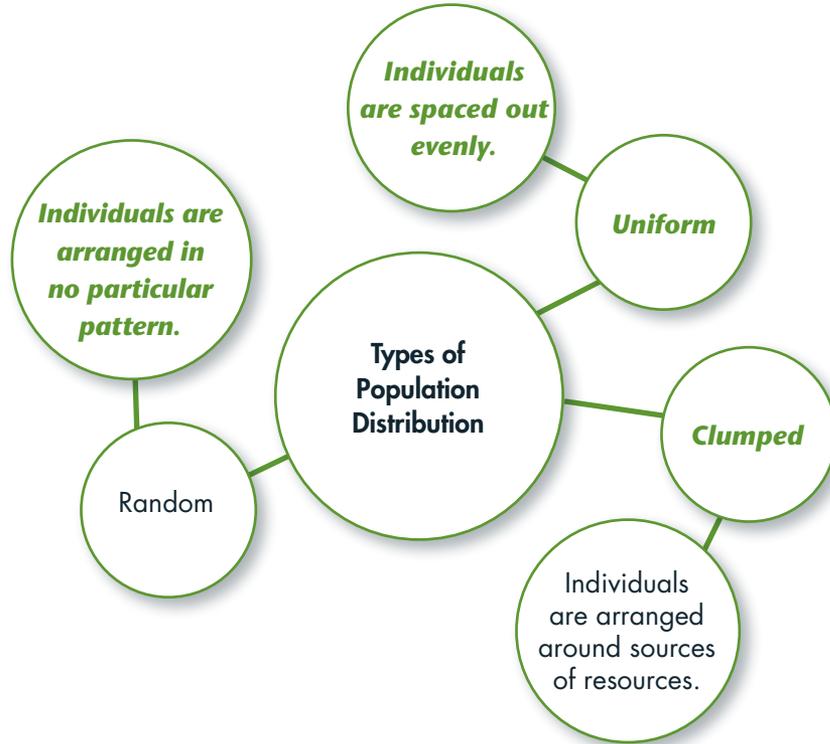
It can make it easier for organisms to form groups and find mates.

9. How can high population density be harmful to a population?

Organisms must compete with each other for limited resources. Also, organisms with a high population density are often more vulnerable to predators and diseases.

Population Distribution

10.  **Organize Information** Fill in the cluster diagram with short descriptions or drawings of the different types of population distribution.



11. Which type of population distribution is found most often in nature?

Clumped

Age Structure and Sex Ratios

12. Describe how to use an age-structure diagram to determine how many males and females are in a population.

Horizontal bars extending to the left at each age range indicate the number of males, while bars extending to the right indicate the number of females. To find the total number of males or females in a population, add all the bars on each side.

13. What will happen to a population made up mostly of individuals that are past reproductive age? *It will decline over time.*

14. What can you predict about a population with an age-structure diagram shaped like a pyramid? *It will experience rapid growth.*



SKILL BUILDER Think Visually

15. Use dots to represent individuals in populations as you contrast the population characteristics in each set below.

A. Population Size

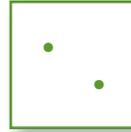


small population



large population

B. Population Density



low density

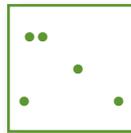


high density

C. Population Distribution



clumped distribution



random distribution



uniform distribution

4.2 SELF-CHECK

Answer the questions to test your knowledge of lesson concepts. You can check your work using the answers on the bottom of the page.

16. Which way of describing a population would be more informative in terms of available resources—population size or population density? Explain. _____

17. Describe how you might use population distribution to find the sources of food or other resources used by a species. _____

18. Explain the significance of an age-structure diagram in which the bars are short along one side and long on the opposite side. _____

16. Population density better indicates the quantity of room and resources available, since it indicates how many organisms are living in a specific area. 17. Populations often distribute themselves according to location of resources. In random or uniform distribution, resources may be widely available; however, if a population is distributed in clumps, these clumps will likely indicate the location of available resources. 18. This indicates that the population consists mostly of either males or females. It may also indicate that the population will not be as successful in reproducing.

4.3 Population Growth

Key Concepts

-  A population's growth rate is determined by births, deaths, immigration, and emigration.
-  Populations can grow exponentially or logistically.
-  Limiting factors and biotic potential regulate a population's growth.



SKILL BUILDER Vocabulary Preview

Define each vocabulary term in your own words. Then, write yourself a quick note on how you will remember each. One term has been done for you.

Term	Definition	How I Remember
Survivorship curve	Graph that shows how the likelihood of death varies with age	Accept all reasonable responses for How I Remember. A few samples are provided.
Immigration	The arrival of individuals from outside a given area	The prefix <i>im-</i> reminds me of "in." That helps me remember that immigration is individuals coming into an area.
Emigration	The departure of individuals from a given area	I think of the letter E, which is also at the beginning of the word exit. That helps me remember what emigration means.
Migration	A seasonal movement into and out of an area	I picture birds migrating in the fall.
Exponential growth	When a population increases by a fixed percentage each year	
Limiting factor	A characteristic of the environment that limits population growth	

Term	Definition	How I Remember
Carrying capacity	The largest population size a given environment can sustainably support	I think of the most I can carry being my carrying capacity. This helps me remember the definition.
Logistic growth	How a population's initial exponential increase is slowed and finally stopped by limiting factors	
Density-dependent factor	A limiting factor whose influence changes with the population density	
Density-independent factor	A limiting factor whose influence is unaffected by population density	
Biotic potential	The maximum ability to produce offspring in ideal conditions	



SKILL BUILDER Reading Strategy

As you read the lesson, complete the main ideas and details chart.

Main Ideas	Details <i>Answers will vary. Sample answers appear below.</i>
Important factors determine population growth.	Natality and mortality of the population are factors in the increase or decrease in growth.
	Survivorship curves show how the likelihood of death varies with age. Immigration and emigration of organisms contribute to the growth or decline of a population.
Populations grow exponentially or logistically.	Exponential growth occurs when a population increases by a fixed percentage each year.
	Logistic growth occurs when the initial exponential growth is slowed or stopped by limiting factors.
A population's growth is regulated by limiting factors and biotic potential.	Limiting factors determine how much population growth is slowed.
	Limiting factors can be density-dependent or density-independent. Biotic potential is the maximum ability to produce offspring in ideal conditions.

Factors That Determine Population Growth

For Questions 1 and 2, complete each statement by writing in the correct word.

1. Populations **increase** when more individuals enter the population than leave it.
2. Populations **decrease** when more individuals leave the population than enter it.
3. Explain how a population would be affected when the birthrate is significantly higher than the death rate and there are no changes due to immigration or emigration.

The size of the population will increase.

4. Describe how emigration and immigration affect the size of a population.

Emigration occurs when individuals depart from an area, causing the population size to decrease. Immigration occurs when individuals arrive, causing the population size to increase.

5. Explain how migration causes population size to change cyclically over time.

Migration occurs as organisms move in and out of an area in a seasonal pattern.

The arrivals create an increase in population size and the exits cause a decrease. In this manner, the population size increases and decreases in a regular pattern.

How Populations Grow

6. Describe the shape of a graph curve indicating exponential growth and a graph indicating logistic growth.

Exponential growth: J-shaped; logistic growth: S-shaped

7. Explain how the availability of resources in the environment is linked to exponential growth of a species.

Exponential growth occurs when resources in the environment are abundantly available to a species.

8. Describe how you can recognize where the carrying capacity for a population occurs on a logistic growth curve.

It occurs where the line flattens out after curving upward.

9. Compare and contrast exponential growth and logistic growth.

Sample answer: Exponential growth usually is short lived and occurs when a population increases by a fixed percentage. In logistic growth, the population rises sharply at first, then levels out as the effects of limiting factors get stronger.

10. Explain how the carrying capacity for a population can change over time.

Limiting factors in nature change constantly, so the carrying capacity also changes.

As more resources or space become available, the carrying capacity can increase.

As predators increase or resources become less available, carrying capacity can decrease.

Limiting Factors and Biotic Potential

11. Circle the factors below that are density-dependent.

climate change

disease

flood

predation

12. Explain why a forest fire is considered to be a density-independent limiting factor.

A forest fire causes a dramatic, sudden reduction in population size. It affects all populations in this way, regardless of whether they are big or small.

13. Give two examples of organisms that differ greatly in their biotic potential.

Organisms such as humans or orangutans have low biotic potential because they produce only one or a few offspring at a time and have a limited time span to produce offspring. Organisms such as bacteria or scorpion fish have high biotic potential; they can produce hundreds of thousands of offspring frequently and with short gestation.

4.3



SELF-CHECK

Answer the questions to test your knowledge of lesson concepts. You can check your work using the answers on the bottom of the page.

14. List two factors that increase the growth rate of a population and two factors that decrease the growth rate of a population.

15. Describe the effects that limiting factors and biotic potential have on a population's growth.

14. Increase: high birthrates, immigration; decrease: high death rates, emigration 15. Limiting factors slow population growth and determine the maximum amount of growth possible in a population. Biotic potential determines the maximum ability to produce offspring under ideal conditions.

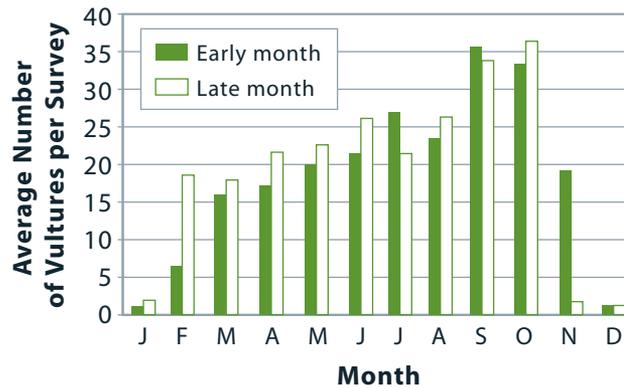
Real Data



Turkey Vultures

The graph at the right shows the average number of turkey vultures that were counted on protected lands at the Hawk Mountain Sanctuary in Pennsylvania. In this activity, you will interpret the graph by describing the trends that it shows and drawing conclusions about the annual migration cycle of turkey vultures.

Turkey Vultures per Survey, 1992–2008



Data from Hawk Mountain Data Archives

Interpreting the Graph

To understand the information in a graph, the first step is to figure out the information that it shows. Study the axes and note the trend shown by the graph.

1. What do the x and y -axes show? ***X-axis: months in a year, y-axis: average number of vultures per survey***
2. What do the two bars for each month represent? ***Light bars are the early part of each month; dark bars are the late part.***
3. To describe the annual trend in the graph, look at the overall changes in the bar height over the entire year. Describe what you see. ***The population is very small in winter. It jumps in late February, then increases through August. In early September it jumps again. The population is larger in September and October.***

Inferring From the Graph

Turkey vultures migrate from the north onto the sanctuary lands and reside there for a while before migrating south. You know that when the vultures migrate through the sanctuary, they will increase the population size. Answer the questions below to help you identify when the vultures migrated through the sanctuary.

4. In which two months is the turkey vulture population significantly greater than in the other months? ***September and October***
5. When would you conclude that the vultures migrating from the north arrive at the sanctuary? ***Early September***
6. When would you conclude that the vultures leave the sanctuary and begin to migrate south? ***Early November***

Chapter Vocabulary Review

Match each term with its definition.

- | | |
|---|---|
| <u> d </u> 1. immigration | a. all the living things and their physical environments within a particular area |
| <u> g </u> 2. sex ratio | b. the number of individuals within a population per unit area |
| <u> k </u> 3. population | c. the largest population size that an environment can sustainably support |
| <u> e </u> 4. habitat | d. the arrival of individuals from outside an area |
| <u> l </u> 5. population distribution | e. the specific environment in which an organism lives |
| <u> h </u> 6. limiting factor | f. occurs when a population increases by a fixed percentage each year |
| <u> i </u> 7. community | g. the proportion of males to females in a population |
| <u> a </u> 8. ecosystem | h. characteristic of the environment that restricts population growth |
| <u> c </u> 9. carrying capacity | i. all the populations in a particular area |
| <u> f </u> 10. exponential growth | j. a group of individuals that interbreed and produce fertile offspring |
| <u> b </u> 11. population density | k. members of a species that live in the same area |
| <u> j </u> 12. species | l. how organisms are arranged within an area |

Use each vocabulary term in a sentence.

13. abiotic factor **Sample answer: Some of the abiotic factors in my environment are the warm temperatures, the sandy soils, and the river that flows by my house.**
14. age structure **Sample answer: The age structure of the population of rabbits showed that the population was mostly made up of young rabbits.**
15. density-dependent factor **Sample answer: Competition is a density-dependent factor in a population because its influence changes with the population density.**

EXTENSION On a separate sheet of paper, create a simple illustration of an ecosystem. Choose five or more vocabulary terms from the chapter to include as labels in your illustration. **Check students' work.**



Finding Gold in a Costa Rican CLOUD FOREST

The Disappearance of the Golden Toad

What can cause a thriving population of animals to disappear in the span of one or two years? In the case of the golden toad of Monteverde in Costa Rica, thousands of toads were initially observed during the

mating season each year. Then one year, there were only a few toads. Two years later, only a single toad was observed, and then the toads disappeared completely.

Environmental Changes

How the golden toads could disappear so quickly is puzzling, but the case is even more mysterious because the habitat of the golden toad was within a large nature preserve. Often, animal populations are devastated as humans or natural disasters destroy their habitats. But this was not the case in the protected Monteverde Cloud Forest Reserve.

Although the toad's environment was not being visibly destroyed, it was changing in subtle ways. For instance, when scientists gathered data on the toad's environment, they noticed a significant increase in the number of "dry days." A "dry day" is designated as a run of five or more days without measurable rain. These dry days resulted in a decrease of available moisture.

Because toads and other amphibians reproduce and live parts of their lives in water, the amount of moisture in the environment affects them to a greater degree than it affects many other species. Of the 50 species of frogs and toads in the study area, 20—including the golden toad—disappeared during the same time frame.

The Lifting Cloud Base Hypothesis has been proposed to explain this widespread amphibian loss in the cloud forest. According to the hypothesis, as the number of "dry days" increased, the base of the clouds that hung over an area rose

in altitude. This caused a decrease in the moisture provided by mist in the forests. As this misty cloud atmosphere rose and was lost, the environment suffered—as plants and animals died off due to the drier climate. This series of events can occur repeatedly.

Many scientists link such series of events to global warming. Others state that the rising cloud base could be caused by deforestation and other human activities. New information also points to another possible scenario that may have killed off the toad. The years following 1986–1987 were exceptionally dry, due to changes in atmospheric and oceanic patterns related to a phenomenon known as El Niño. The exceptional climate conditions during that period could have contributed to the growth and spread of a deadly pathogen—the chytrid fungus—to which the toad was susceptible. The chytrid fungus grows rapidly in warm, dry climates. The fungus has caused declines in amphibians throughout Costa Rica and may have wiped out the golden toad as the weather in the region became warmer and drier. Scientists warn that although amphibians in this ecosystem are the first organisms to disappear when environmental conditions change, other species of organisms and plants may follow.

Use the information in **The Disappearance of the Golden Toad** to answer the questions below.

1. How many golden toads could be observed during mating season when the toad's population was thriving? **Thousands**
2. Based on the golden toad population's habitat, why was extinction of the golden toad puzzling? **Sample answer: The habitat of the golden toad population was in a protected environment. There was no development or destruction of the habitat.**
3. Explain why it was significant that large numbers of other frogs and toads became extinct at the same time the golden toads disappeared.
Sample answer: The extinction of other frog and toad species would seem to indicate that an essential factor common to amphibians was responsible.
4. Explain what happens to cloud mist as the number of "dry days" increases.
As the number of "dry days" increases, the cloud mist that hangs over an area rises.
5. Assuming the Lifting Cloud Base Hypothesis to be correct, which part of the Monteverde cloud forest would likely be the least affected by the decrease in moisture? Explain.
Sample answer: The upper area that is still surrounded by the cloud base would likely be the least affected, as it would hold more moisture than the area below.
6. **BIG QUESTION** Relate this case to the Big Question: "How do changes in population size relate to environmental conditions?" Describe the sequence of events that could have led to the extinction of the golden toad, according to the Lifting Cloud Base Hypothesis.
Sample answer: As global temperatures increased, the climate became drier in the cloud forest. As the climate became drier, the cloud mist shrank and retreated upward. As the cloud mist retreated upward, the habitat of the golden toad became less hospitable, and it began to die out.

21st Century Skills

Find out more about other extinctions that occurred in the Monteverde region during this time period. Work in small groups to use the Internet and other resources to learn more about what caused the extinctions you have been studying. Each group should create a poster or presentation to share with the class.

*The 21st Century Skills used in this activity include **Communication and Collaboration, Information Literacy, and Productivity and Accountability.***



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*Log on for more information and activities on the Central Case, **Finding Gold in a Costa Rican Cloud Forest.***